RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)

DATE: February 1999

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603203F Advanced Aerospace Sensors

	COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	23,944	28,534	29,405	32,330	33,587	31,561	30,209	31,749	Continuing	Continuing
665A	Advanced Aerospace Sensors Technology	11,316	13,481	15,070	17,249	18,033	15,012	13,286	14,495	Continuing	Continuing
69CK	Advanced Electronics	1,114	1,562	815	952	1,430	2,080	2,084	2,088	Continuing	Continuing
69DF	Target Attack and Recognition Technology	11,514	13,491	13,520	14,129	14,124	14,469	14,839	15,166	Continuing	Continuing
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

(U) A. Mission Description: This Advanced Technology Development program develops technology to enable continued sensors superiority from space and aerial platforms. Combat aircraft must defeat increasingly sophisticated active and passive countermeasures, destroy a wide variety of targets with precision under a myriad of environmental conditions, and reliably perform complex missions with less logistics support in a world of proliferating threats. This program responds to these needs by developing and demonstrating the means to find, fix, target track and engage air and ground targets, anytime, anywhere, and in any weather. Specifically, this program develops the aerospace radio frequency sensors (i.e., radar) and electro-optical sensors for detecting, locating, and targeting airborne, fixed, and time-critical mobile ground targets, whether those targets are obscured by natural or man-made means, while providing the capability to adapt to changes in target signatures and background environments. These advanced sensor capabilities will provide for flexible, multi-function/multi-mission combat aircraft that can: safely penetrate threat areas; destroy multiple ground targets per pass; accurately detect and identify targets beyond-visual-range within a complex mix of look-alike friendly, neutral, and enemy aircraft; win aerial engagements; and return to fight again. Note: In FY 1999, Congress added $2.2 million for the Enhanced Recognition and Sensing Ladar (ERASER) program.

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(U) B. Budget Activity Justification: This program is in Budget Activity 3, Advanced Technology Development, since it develops and demonstrates technologies for existing system upgrades and/or new sensor and electronic combat system developments that have military utility and address warfighter needs.

(U) C. Program Change Summary ($ in Thousands):

	FY 1998	FY 1999	FY 2000	FY 2001	Total Cost
(U) Previous President's Budget/FY 1999 PB	25,077	26,442	25,148	26,269	Cont
(U) Appropriated Value	26,507	28,642			
(U) Adjustments to Appropriated Value					
a. Congressional/General Reductions	-879	-108			
b. SBIR	-571				
c. Omnibus/Other Above Threshold Reprogrammings	-170				
d. Below Threshold Reprogrammings	-943				
(U) Adjustments to Budget Year Since FY1999 PB			4,257	6,061	
(U) Current Budget Submit/FY 2000 PB	23,944	28,534	29,405	32,330	Cont

(U) Significant Program Changes: Outyears reflect program redirection to increase development of space-based sensor technology.

FY 1999: $780 identified as a source for SBIR.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)

DATE: February 1999

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603203F Advanced Aerospace Sensors

PROJECT: 665A

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
665A Advanced Aerospace Sensors Technology	11,316	13,481	15,070	17,249	18,033	15,012	13,286	14,495	Continuing	Continuing

(U) A. Mission Description: Develops and demonstrates aerospace sensor technologies for manned and umanned platforms, including electro-optical (EO) sensors, radars, and electronic counter-countermeasures (ECCM) for radars. This project will provide warfighters with the capability to precisely detect and target both airborne targets (conventional and low radar cross section) and ground-based, high-value, time-critical targets from air and space-based platforms. Work includes developing both complete sensor capabilities as well as advanced component technologies. The desired warfighting capability includes the ability to detect and target in difficult background conditions, with emphasis on countering improvements in camouflage, concealment, and deception techniques that limit current detection and tracking capability for threats obscured by these means. Note: In FY 1999, Congress added $2.2 million for Enhanced Recognition and Sensing Ladar (ERASER) technologies.

(U) FY 1998 ($ in Thousands):

- (U) $2,194 Developed integrated air-to-air and air-to-ground EO sensor technologies to detect, locate, and identify targets at ranges longer than currently achievable, whether the targets are camouflaged, low-observable, or employing other means of deception. This included design of a day/night multispectral sensor and initiation of a multinational program for affordable precision targeting at standoff ranges.
- (U) $2,326 Developed airborne, air-to-ground wind profiling technologies to enhance accuracy of bomb drops and cargo delivery, including demonstration of a modular wind profiler and designing a wind sensor.
- (U) $1,241 Developed and demonstrated radar ECCM techniques to negate air intercept and synthetic aperture radar electronic countermeasures, including development of concepts for using neural nets to counter jamming.
- (U) $2,945 Developed processing techniques to negate clutter and electromagnetic interference, both intentional and unintentional, for uninterrupted sensor performance and increased detection and targeting performance against sophisticated and low radar cross section targets, including refinement and demonstration of adaptive processing techniques for improving radar performance under severe jamming.
- (U) $1,117 Developed and demonstrated the radio frequency sensor and algorithm technology required to detect, identify, and target high-value, time-critical targets obscured by foliage or concealed through deceptive techniques, including a joint Air Force/Army/Defense Advanced Projects Research Agency demonstration of real-time automated detection algorithms for unmanned aerial vehicle-sized radars.
- (U) $1,493 Developed critical components required to lower life cycle cost of current and future radar systems, including flight tests of an advanced air platform antenna for precision weapon delivery.
- (U) $11,316 Total

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BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603203F Advanced Aerospace Sensors
	PROJECT 665A

(U) FY 1999 ($ in Thousands):

- (U) $3,953 Develop integrated electro-optical (EO) sensor technologies to detect, locate, and identify targets at ranges longer than currently achievable, whether the targets are camouflaged, low-observable, or employing other means of deception. This includes fabricating an EO sensor that operates in day or night across multiple bands.
- (U) $1,482 Develop and demonstrate radar electronic counter-countermeasure techniques to negate air intercept and synthetic aperture radar electronic countermeasures, including assessing use of neural nets to identify and remove jamming waveforms.
- (U) $3,543 Develop processing techniques to negate clutter and electromagnetic interference, for uninterrupted sensor performance and increased detection and targeting performance against sophisticated and low radar cross section targets, including conducting laboratory and rooftop demonstrations of advanced mitigation techniques for severe interference and jamming environments.
- (U) $3,253 Develop the radio frequency (RF) sensor and algorithm technology required to detect, identify, and target high-value, time-critical targets obscured by foliage or concealed through deception, including ground testing real-time image formation/interference mitigation for foliage penetrating synthetic aperture radars.
- (U) $882 Develop critical components required to lower life cycle cost of current and future radar systems, including flight testing an affordable antenna suitable for unmanned vehicles.
- (U) $368 Identified as a source for SBIR.
- (U) $13,481 Total

(U) FY 2000 ($ in Thousands):

- (U) $1,700 Develop integrated electro-optical (EO) sensor technologies to detect, locate, and identify targets at ranges longer than currently achievable, whether the targets are camouflaged, low-observable, or employing other means of deception. This includes completing fabrication and initiating flight test of an EO sensor that operates in day or night across multiple bands.
- (U) $4,587 Develop EO sensor technologies to detect and locate deep hide targets from high altitudes and space, including collecting infrared sensor model validation data, conducting space sensor trade studies, and creating hyperspectral imaging/fusion algorithms.
- (U) $2,204 Develop radar signal processing techniques to negate clutter and interference and improve detection and tracking of difficult targets, including developing adaptive processing for fighter detection of low-observable targets, demonstrating improved radar performance via enhanced antenna implementation, and developing integrated processing methods for improved ground target detection and tracking.
- (U) $3,419 Develop RF sensor and algorithm technology required to detect, identify, and target high-value, time-critical targets obscured by foliage or obscured by deceptive techniques, including flight testing image formation processing and automatic target detection.
- (U) $1,576 Develop technology to lower life cycle costs of radar systems, including laboratory testing low-cost digital receivers and sensor components, evaluating space-based apertures using micro-electro-mechanical systems phase shifters, and demonstrating a millimeter wave array for high-altitude unmanned aerial vehicles.

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BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603203F Advanced Aerospace Sensors
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- (U) $1,584 Develop technology for non-cooperative target identification, including building high resolution algorithms, validating models, flight testing sensor hardware, and evaluating laser vibration as a solution to target identification.
- (U) $15,070 Total

(U) FY 2001 ($ in Thousands):

- (U) $5,715 Develop EO sensor technologies to detect and locate deep hide targets from high altitudes and space, including completing infrared sensor model validation data collection, analyzing sensor performance, completing space sensor trade studies, and testing hyperspectral imaging and fusion algorithms.
- (U) $2,908 Develop radar signal processing techniques to negate clutter and interference and improve difficult target detection and tracking, including flight testing use of adaptive processing for detecting slow moving targets in presence of jamming, developing techniques using highly integrated avionics systems, and developing advanced processing methods.
- (U) $3,797 Develop and demonstrate the radio frequency sensor and algorithm technology required to detect, identify, and target high-value, time-critical targets obscured by foliage or concealed through deceptive techniques, including completing flight tests of real-time image formation and automatic target detection algorithms.
- (U) $1,090 Develop technology to lower life cycle costs of radar systems, including field testing low-cost, lightweight, low-power, micro-electro-mechanical system-based apertures.
- (U) $2,180 Develop technology for non-cooperative target identification, including designing a sensor for transition risk reduction, testing high resolution algorithms, analyzing sensor suite utility, and flight testing a sensor suite.
- (U) $1,559 Develop, with international partners, the EO sensor technology needed to integrate wide-area search with non-cooperative identification for automated standoff surveillance, identification, and targeting, including designing and fabricating flight-worthy hyperspectral sensor and laser identification channels and optimizing sensor suite trade studies.
- (U) $17,249 Total

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BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603203F Advanced Aerospace Sensors
	PROJECT 665A

(U) B. Project Change Summary - Description of Significant Changes: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:

- (U) PE 0602204F, Aerospace Sensors.
- (U) PE 0603205F, Flight Vehicle Technology.
- (U) PE 0603707F, Weather Systems Advanced Development.
- (U) PE 062111N, Weapons Technology.
- (U) PE 062232N, Space and Electronic Warfare (SEW) Technology.
- (U) PE 0604249F, LANTIRN Night Precision Attack.
- (U) PE 0603270F, Electronic Combat Technology.
- (U) A memorandum of agreement has been established between the Air Force Research Laboratory and the Defense Advanced Research Projects Agency (DARPA) to jointly develop the technology required to detect high-value, time-critical targets in a variety of environments including deception, camouflage, concealment, and deep hide.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603203F Advanced Aerospace Sensors PROJECT 69CK

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
69CK Advanced Electronics	1,114	1,562	815	952	1,430	2,080	2,084	2,088	Continuing	Continuing

(U) A. Mission Description: Develops and demonstrates military specific microwave, microelectronic, and photonic devices, tools, and components that improve performance, reliability, and affordability of aerospace radar, communications, and electronic counter-countermeasure systems for both retrofit and new system applications. Results provide the warfighter with increased sensor capabilities in terms of increased situational awareness, higher accuracy detection and tracking of targets/threats at longer ranges, and more precise weapon employment. This project develops electronics technologies unavailable from commercial sources and includes development of: aerospace radar monolithic solid state transmit/receive modules; high-speed analog-to-digital converters; photonic processing techniques, high reliability electronics power distribution; microwave/microelectronics packaging and interconnect techniques; and radio frequency (RF) photonic distribution subsystems.

(U) FY 1998 ($ in Thousands):

- (U) $423 Developed advanced microelectronics components, power distribution, packaging, and interconnect technologies to reduce power consumption, cost, weight, and volume of emerging military systems. Efforts included demonstration of inorganic coatings for encapsulating microcircuits and development of advanced power supplies for multi-function phased array radars.
- (U) $445 Developed advanced multi-function sensor electronics, such as integrated analog/digital applications, to increase reliability, improve performance, and decrease avionics cost, weight, and volume. This included optimization of very high-speed digital assemblies, development of packaging technologies for minimum size transmit/receive modules, and demonstration of a miniature analog/digital microwave receiver.
- (U) $246 Developed advanced design automation tools and methods for creating complex electronics/avionics. These tools will significantly lower the development cost and subsequent support costs of all electronic systems, including demonstrating the speed of automated design tools.
- (U) $1,114 Total

(U) FY 1999 ($ in Thousands):

- (U) $1,519 Develop advanced multi-function sensor electronics, including integrated analog/digital applications, to increase reliability, improve performance and jam resistance, and decrease cost, weight, and volume in aerospace sensors. Efforts include continued development of very high-speed digital assemblies, fabricating and testing high performance RF/digital multichip assemblies and completing preliminary designs for miniature, all-digital microwave receiver components.
- (U) $43 Identified as a source for SBIR.
- (U) $1,562 Total

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	PROJECT 69CK

(U) FY 2000 ($ in Thousands):
- (U) $458 Develop advanced multi-function sensor electronics, including continued development of affordable, high performance radio frequency (RF) circuits and packaging technologies for use in phased array transmit/receive modules on manned and unmanned platforms.
- (U) $357 Perform application trade studies for space-based photonics RF signal distribution, including photonic beamforming for Global Positioning System (GPS) applications.
- (U) $815 Total

(U) FY 2001 ($ in Thousands):
- (U) $525 Develop advanced multi-function sensor electronics, including low-cost multi-chip module/sub array coating approaches. Demonstrate affordable, high performance RF circuits and packaging technologies for use in phased array transmit/receive modules on manned and unmanned platforms.
- (U) $237 Develop analog, digital, and microwave/millimeter wave photonics technology for compact, affordable, optically-controlled RF aerospace applications, including designing dynamically reconfigurable RF signal distribution components, and demonstrating photonic components for wide bandwidth, high-throughput optical processing.
- (U) $190 Develop high performance RF phased array antenna controls for extremely wide angle coverage, including testing and integrating a photonics true-time-delay processor and fabricating and testing an anti-jam GPS antenna. (In FY 2000, this effort was conducted under PE 0603726F, Project 2863.)
- (U) $952 Total

(U) B. Project Change Summary - Description of Significant Changes: Changes to this project since the previous President's Budget are due to higher priorities within the Science and Technology (S&T) Program.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0602204F, Aerospace Sensors.
- (U) PE 0603270F, Electronic Combat Technology.
- (U) PE 0603739E, Electronic Manufacturing Technology.
- (U) PE 0603706E, Microwave/Millimeter Wave Integrated Circuits.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY: 3 - Advanced Technology Development	PE NUMBER AND TITLE: 0603203F Advanced Aerospace Sensors — PROJECT: 69DF

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
69DF Target Attack and Recognition Technology	11,514	13,491	13,520	14,129	14,124	14,469	14,839	15,166	Continuing	Continuing

(U) A. Mission Description: Develops and demonstrates advanced technologies for attack management, fire control, and target identification and recognition. This includes developing and demonstrating integrated and cooperative fire control techniques to provide for adverse-weather precision air strikes against multiple targets per pass at maximum weapon launch range. Specific fire control technologies include attack management, sensor fusion, automated decision aids, advanced tracking for low radar cross section threats, and targeting using both on-board and off-board sensor information. These fire control developments will provide force multiplication and reduce exposure to hostile fire. This project also develops and demonstrates technologies for positive, high confidence cueing, recognition, and identification of airborne and ground-based, high-value, time-critical targets at ranges compatible with tactical air-to-air and air-to-surface weapons in all weather, day or night, and in high-threat, multiple target battle areas. Model-based vision algorithms and target signature development techniques are key to target identification and recognition and are pursued in this project in partnership with the Defense Advanced Research Projects Agency. The techniques developed are evaluated to support the Theater Missile Defense efforts in surveillance and attack. The fire control and recognition technologies developed and demonstrated in this project are high leverage, providing for significant advancements in operational capabilities largely through software improvements readily transitioned to new and existing systems.

(U) FY 1998 ($ in Thousands):

- (U) $3,607 Developed and demonstrated advanced air-to-air detection, tracking, identification, and engagement technologies, including transition of synthetic signature generation capability for hostile airborne target identification, investigation of advanced sensor suites using off-board sources, development of a preliminary design for all-aspect fire control, and completion of ground-to-air testing of combined radar modes.
- (U) $2,225 Developed advanced situation awareness technologies to increase air-to-ground engagement lethality and survivability, including design of a real-time information out of the cockpit approach to improve battle damage assessment, demonstration of embedded multi-source fusion of electronic intelligence and synthetic aperture radar data, and development of a concept for real-time embedded multi-source fusion.
- (U) $5,682 Developed and demonstrated innovative air-to-ground Automatic Target Recognition (ATR) and identification technologies to increase capacity to detect, identify, and target hostile ground forces, including development and integration of ATR/fusion design testbed, evaluation of use of current algorithms for longer timelines of reconnaissance platform radars, measurement of the performance of air-to-ground ATR algorithms using enhanced radar with third generation forward looking infrared and multispectral ATR, and completion of a critical design for modifications to a fire control radar for advanced identification of ground forces.
- (U) $11,514 Total

(U) FY 1999 ($ in Thousands):

- (U) $1,563 Develop and demonstrate advanced air-to-air detection, tracking, identification, and engagement technologies, including continuing to investigate advanced sensors suites, and analyzing ground test data for target identification through combined radar modes.

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- (U) $6,663 Develop advanced situation awareness technologies to increase air-to-ground engagement lethality and survivability, including continuing to demonstrate multisource fusion of electronic intelligence with synthetic aperture radar (SAR), flight demonstrating real-time rerouting of an low-observable platform using real-time information in the cockpit (RTIC) technology, and developing and flight testing fusion of forward looking infrared and SAR data on an interdiction fighter.
- (U) $4,896 Develop and demonstrate innovative air-to-ground Automatic Target Recognition (ATR) and identification technologies to increase the ability to detect, identify, and target hostile ground forces, including continuing to develop and integrate an ATR/fusion algorithm testbed, downselecting and integrating an optimal algorithm for longer timelines of reconnaissance radars, performing detailed analysis of air-to-ground ATR algorithms using enhanced radar with third generation forward looking infrared and multispectral ATR and demonstrating the identification of friendly and hostile ground forces.
- (U) $369 Identified as a source for SBIR.
- (U) $13,491 Total

(U) FY 2000 ($ in Thousands):

- (U) $2,699 Develop advanced situation awareness technologies for rapid detection, location, and prosecution of time-critical targets, including demonstrating ground station fusion of SAR and signals intelligence and developing on-board/off-board data and image fusion algorithms.
- (U) $2,947 Develop and demonstrate RTIC technologies, including continuing to flight demonstrate and simulate real-time route replanning and retargeting for stealth strike platforms and developing real-time retargeting algorithms for special operation forces.
- (U) $1,577 Develop and evaluate radar ATR algorithms for tracking moving ground targets, including evaluating radar algorithms for tracking moving ground targets and reducing transition risk by planning affordable upgrades to strike and reconnaissance platforms.
- (U) $ 1,214 Develop target recognition concepts using hyperspectral imaging and other candidate sensor inputs to determine requirements for ATR and target/background phenomenology efforts, including building algorithms using hyperspectral imaging data.
- (U) $3,004 Test and integrate Defense Advanced Research Projects Agency multi-sensor ATR fusion algorithms into the Air Force ATR evaluation test facility for application to Air Force intelligence, surveillance, and reconnaissance functions.
- (U) $2,079 Develop advanced tactical targeting technology in conjunction with Defense Advanced Research Projects Agency (DARPA) for suppression of enemy air defenses, including hardware-in-the-loop testing against threat radio frequency (RF) signals.
- (U) $13,520 Total

(U) FY 2001 ($ in Thousands):

- (U) $2,131 Develop advanced situation awareness technologies for rapid detection, location, and prosecution of time-critical targets, including demonstrating algorithms for fusion of on- and off-board data and images.
- (U) $1,900 Develop and demonstrate real-time information in the cockpit (RTIC) technologies, including completing RTIC simulations and continuing to develop real-time retargeting algorithms for special operation forces applications.

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- (U) $2,329 Demonstrate and laboratory test algorithms for tracking moving ground targets, emphasizing risk reduction for transition via planned sensor upgrades to strike and reconnaissance platforms.
- (U) $1,664 Develop target recognition concepts using hyperspectral imaging and other candidate sensor inputs to determine requirements for automatic target recognition (ATR) and target/background phenomenology efforts, including evaluating algorithms using hyperspectral imaging data.
- (U) $2,618 Continue testing and integrating Defense Advanced Research Projects Agency multi-sensor automatic target recognition fusion algorithms into the Air Force ATR evaluation test facility for application to Air Force intelligence, surveillance, and reconnaissance functions.
- (U) $300 Develop technology to evaluate advanced air-to-air fire control and tracking algorithms, including performing sensor-to-shooter trade studies.
- (U) $3,187 Develop advanced tactical targeting technology in conjunction with DARPA for suppression of enemy air defenses, including ground demonstration of brassboard units that triangulate threat emitter position and provide targeting for precision guided munitions.
- (U) $14,129 Total

(U) B. Project Change Summary - Description of Significant Changes: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0602204F, Aerospace Sensors.
- (U) PE 0603253F, Advanced Sensor Integration.
- (U) PE 0603726E, Sensor and Guidance Technology
- (U) Theater Missile Defense System Program Office.
- (U) Low Altitude Night Targeting and Infrared Navigation (LANTIRN) System Program Office.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

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